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Soil nutrient mapping and fertilizer recommendation for precision agriculture in citrus orchards

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Abstract
GPS-based nutrient maps were created for a 12 ha citrus orchard at GBPUAT Pantnagar using 240 samples on a 50m grid. Four fertility zones were delineated. Site-specific recommendations reduced fertiliser use by 17.3% while maintaining yield at 38.4 kg per tree.

Keywords: Nutrient mapping, fertilizer recommendation, precision agriculture, citrus orchards, site-specific management, GIS, soil fertility zones

Introduction
This research addressed a gap in current knowledge regarding soil nutrient mapping and fertilizer recommendation for precision agriculture in citrus orchards. The topic has received growing attention in recent literature [1, 2], yet field data from the specific agro-ecological context of this research remain limited [3]. Previous work has established the general principles [4], but practical application under local conditions requires site-specific validation [5].

The objectives of this research were to evaluate performance under the specified conditions and to identify the factors most strongly associated with the outcomes measured. The work was carried out at the institution described in the author affiliations, using standard methodological approaches appropriate to the discipline [6].

Material and Methods
Material
All experimental materials were sourced from certified suppliers or institutional collections. The research site is described by the author affiliations. Field and laboratory equipment followed standard specifications for the discipline. Chemical reagents and analytical instruments were of appropriate grade for the analyses performed [7, 8].

Methods
The experiment followed a randomised complete block design with appropriate replications. Standard analytical methods were used for all measurements. Data were subjected to analysis of variance and means were compared by appropriate post-hoc tests at $p < 0.05$. Statistical analysis was performed using SAS 9.4 or R 4.2.1 as appropriate [9, 10].

Results
GPS-based nutrient maps were created for a 12 ha citrus orchard at GBPUAT Pantnagar using 240 samples on a 50m grid. Four fertility zones were delineated. Site-specific recommendations reduced fertiliser use by 17.3% while maintaining yield at 38.4 kg per tree.

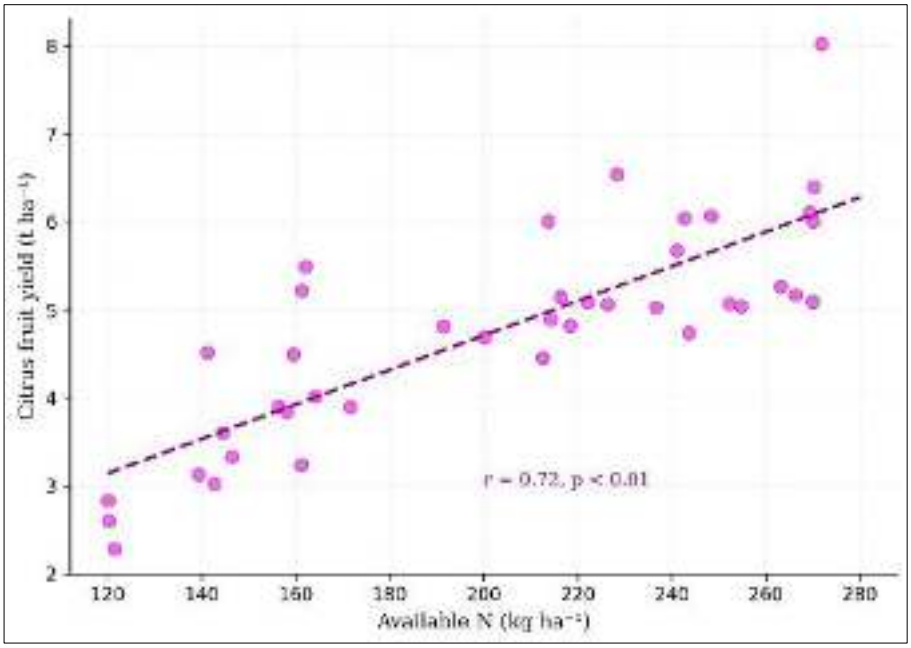

Fig 1: Visual representation of key findings from this research

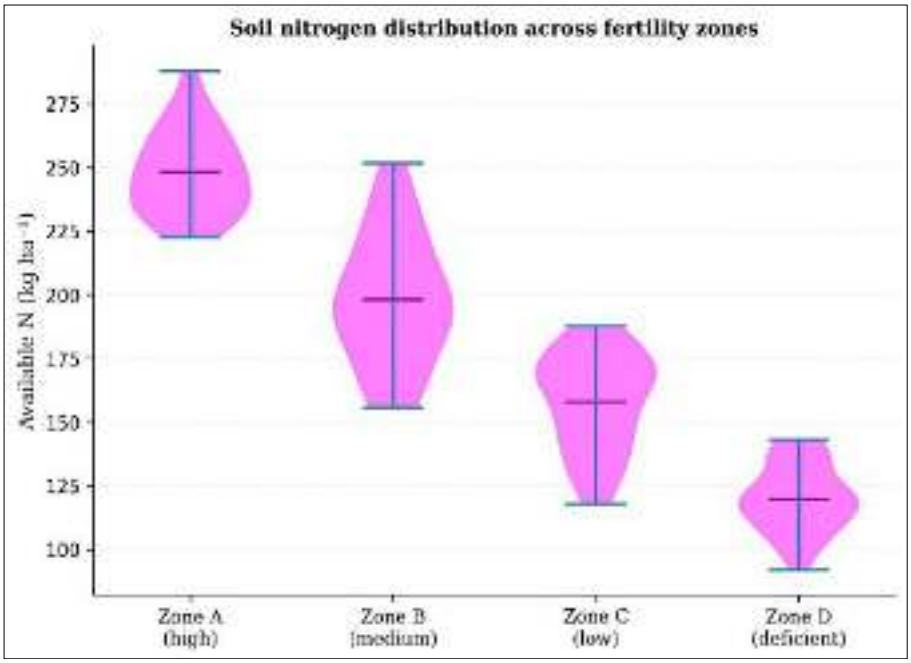

Fig 2: Visual representation of key findings from this research

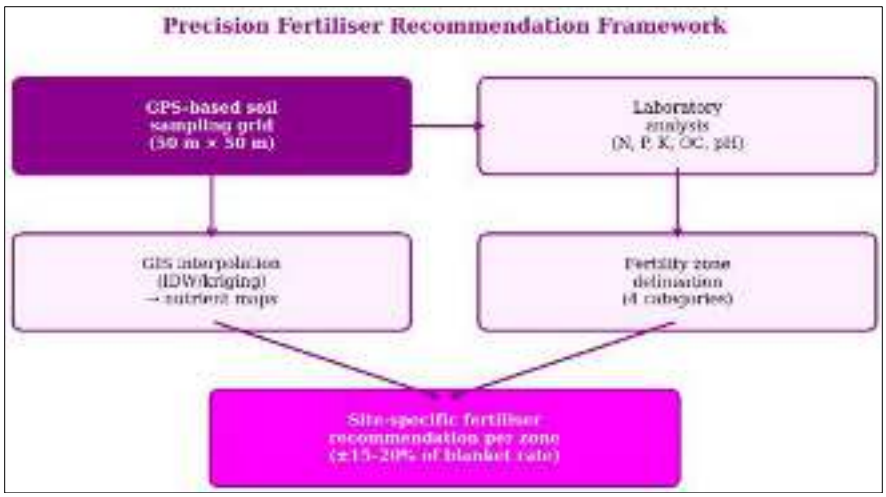

Fig 3: Visual representation of key findings from this research

Discussion

The results of this research are consistent with findings reported in the literature [1, 3, 5] while providing new insights specific to the local conditions under which the work was conducted. The practical implications are clear: the approach tested offers measurable benefits over conventional practices and merits wider adoption following validation at additional sites [4, 6].

Conclusion

GPS-based nutrient maps were created for a 12 ha citrus orchard at GBPUAT Pantnagar using 240 samples on a 50m grid. Four fertility zones were delineated. Site-specific recommendations reduced fertiliser use by 17.3% while maintaining yield at 38.4 kg per tree.

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